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NEURAL-METHOD ALLOYS IDENTIFICATION BY THE MICROPLASMA OXIDATION PROCESS IN THE ELECTROLYTE SOLUTIONS

FUNCTIONAL ELECTRICAL AND ELECTRONIC MATERIALS AND DEVICES

Abstract: A new method of the aluminium and magnesium alloys identification is described in the paper. The distinctive feature of method is based on the measure of parameter current by the microplasma oxidation process of the alloys using neural network for its identification. Example of alloy identification and estimation of recognition accuracy are given.
Keywords: artificial neural networks, microplasma process, identification, electrical parameters.

1. INTRODUCTION

It is possible to identify of physical objects by methods using observation the object response on external effect. In electrochemical researches the electric signals are used as external effect.

In the developed method for identification of the aluminium and magnesium alloys, it is offered to use the researched object as a working electrode in the electrochemical cell connected to the voltage pulse source that occurred of the anode spark, or microplasma process.

Electric current carried out the electrochemical transformations and in consequence, a change of internal structure of object under investigation, and occurrence of oxide covering. The current form through the electrochemical cell carries itself the information of structure of the oxide coverings, as well as material of the working electrode which investigated object is used [1].

The microplasma process is the complex process including plasma, chemical and electrochemical reactions. It is difficult to precisely describe the functional dependence of the system response on effect. Therefore, it is offered to use the artificial neural network method for alloy identification, which has some efficiency by adaptive structure with takes data, learns and captures quite suitable relationships also in complex interactions between input/output information [2]. In this case the identification problem is reduced to a problem of recognition of response image.

2. IDENTIFICATION METHOD

As an image for recognition of the neural network, the current pulse received as a result of influence on the electrochemical cell (Fig. 1) is used for identification of alloy. It carries out itself the information on many parameters of microplasma oxidation process, including structure of the electrode alloy. As a classifying attributes, the maximal value of current I_1 and pulse amplitude in steady state mode I_2 are chosen (Fig. 2). Experimental data has shown that these two parameters vary on alloy kind most essentially.

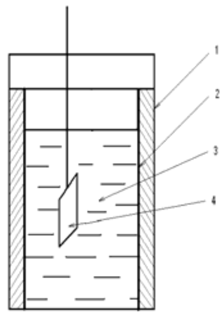

Fig. 1. The electrochemical cell structure:
1 – ceramic beaker, 2 – auxiliary electrode, 3 – electrolit, 4 – working electrode

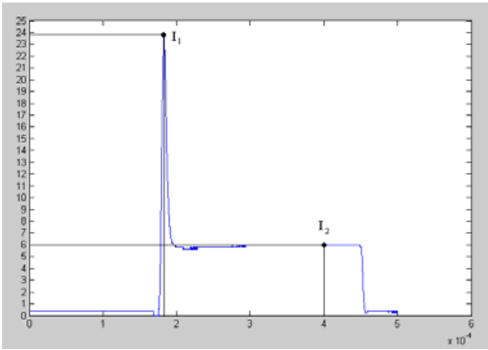

Fig. 2. Pulse of current in the electrochemical cell

The problem of alloy identification is solved by neural network formation, its preliminary training to a known complex of characteristics (image), and its further application for identification of the investigation samples.

3. EXAMPLE

For confirmation of the method, identification of 4 aluminium and magnesium alloys was carried out by neural network. Training of the neural networks was carried out based on a data of current, received at impact of the four componental electrolit on samples of microplasma sparks in the water solution.

Experiment was carried out as follows. For neural network training the electric parameters of the electrochemical cell was measured. The cell represented itself a ceramic beaker by diameter of 110 mm and height 110 mm. An auxiliary electrode was made from stainless steel by thickness of 2 mm, having the ring form on internal diameter of the beaker. The surface of the auxiliary electrode in 100 and more times exceeded a surface of the working electrode in all cases. Samples from 4 various alloys of aluminium and magnesium (*Al*2021, *Al*7071, *AMg*, *AZ*91*D*) served as a working electrode. Pulses of voltage from the pulse generator (Fig. 3) to a sample raises microplasma sparks in the water solution of 4-componental electrolit, g/l:

$Na_2HPO_4 \times 12\ H_2O$ – 3;

$Na_2B_4O_7 \times 10\ H_2O$ – 12;

H_3BO_3 – 3;

NaF – 3.

Behavior of current from investigated alloy in 5 minutes after the beginning of microplasma process is presented in Fig. 4.

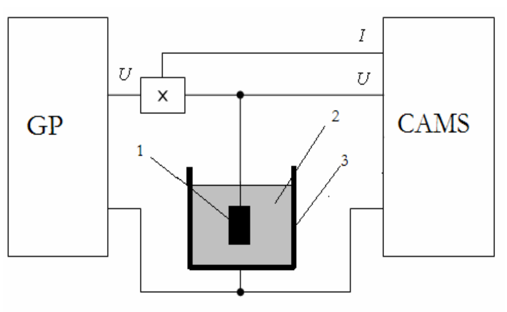

Fig. 3. Block diagram of the experimental device: 1 – analyzed alloy, 2 – electrolit, 3 – beaker with the auxiliary electrode, GP – generator of pulse, CAMS – Computer-Aided Measurement System

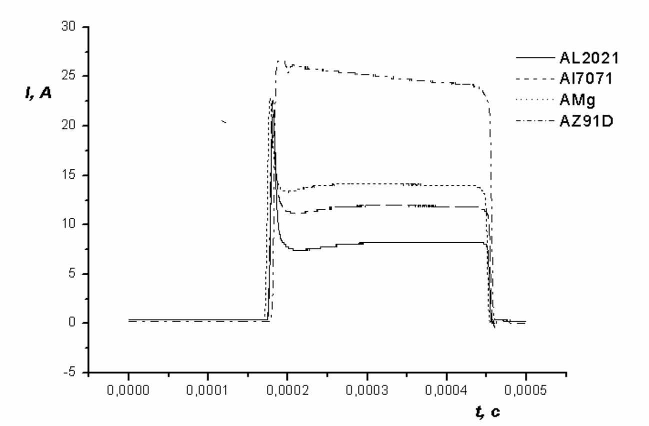

Fig.4. Pulse of current for the different alloys

For example of neural network, a single-layered perceptron was chosen. It consists of three neurons, two inputs, and three outputs (Fig. 5). Function of unit pulse in Fig. 6 was chosen as activation function of neuron.

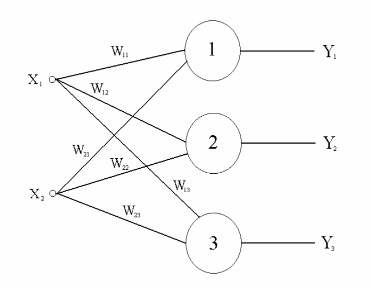

Fig. 5. Block diagram of neural network

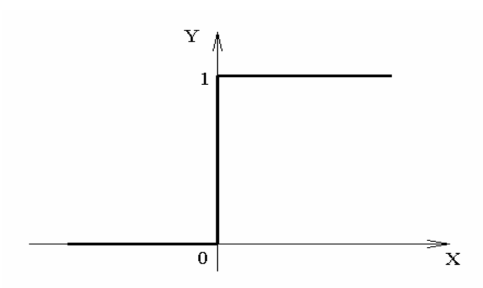

Fig. 6. Activation function

On X_1 and X_2 inputs the I_1 and I_2 parameters is impacted. The kind of an alloy is defined by form of output signals Y_1, Y_2, Y_3.

The given model can be described by the following system of equations:

$$\begin{cases} Y_1 = h(X_1W_{11} + X_2W_{21}) \\ Y_2 = h(X_1W_{12} + X_2W_{22}) \\ Y_3 = h(X_1W_{13} + X_2W_{23}) \end{cases}, \quad (1)$$

where: Y_1, Y_2, Y_3 are output signals;

X_1, X_2 are input signals;

W_{ij} are weight coefficients;

h is activation function of neuron (unit pulse).

Adjustment of the weight coefficients was carried out basing on the data for training (Table 1).

Table 1. – Data for the neural network training

Kind of alloy	Classifying attributes		Output of the neural network		
	I_1, A	I_2, A	Y_1	Y_2	Y_3
*Al*2021	21,2	8,2	0	0	0
*Al*7071	22,6	12	0	1	0
AMg	22,8	14,2	1	1	0
*AZ*91*D*	26,6	25,2	1	1	1

After substitution of weight coefficients in expression (1), the system of equations is turns out:

$$\begin{cases} Y_1 = h(-22X_1 + 40X_2) \\ Y_2 = h(-20X_1 + 40X_2) \\ Y_3 = h(-5X_1 + 7X_2) \end{cases}. \quad (2)$$

Variables Y_1, Y_2, Y_3 are Boolean (0 or 1). A combination of 0 and 1 on the system output corresponds to each kind of alloy.

Recognition of four various alloys of aluminium and magnesium was simulated basing on Neural Networks Toolbox (Fig. 7).

After training the neural network the following kind of alloys was capable to recognize: Al2021, Al7071, AMg, AZ91D.

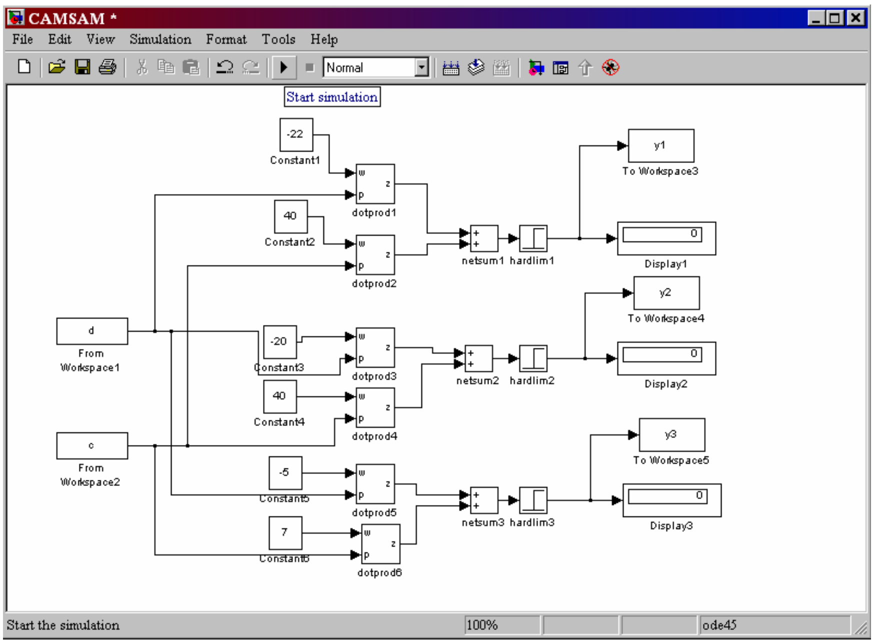

Fig. 7. Neural Network

4. CONCLUSION

The developed method belongs to the analysis of chemical and physical properties of materials by definition of their electrochemical parameters with use of digital calculations and data processing. It may be used in metallurgy, metal working and mechanical engineering for quality control of production [3]. The error of recognition *P* was made for estimation of identification quality. The error of recognition is expressed in percentage and calculated as follows:

$$\mathrm{P} = \frac{N - N^*}{N} \cdot 100\,\%, \quad (3)$$

where: *P* is error of recognition;

N is a quantity of identified samples;

*N** is a correct quantity of samples.

Forty measurements – 10 on each kind of alloy was carried out for estimation of error of recognition. Correct recognition was 37 from 40 samples. Thus, the recognition error was 7.5%.

It is necessary to note that accuracy of recognition depends on neural network architecture, from neuron amount, and from correct adjustment of weight coefficients.

Under testing of the method on multi-layer neural network the error of the recognition was less than 0.1%.

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